OPTICAL SCANNER

Patent Number: JP2109012
Publication date: 1990-04-20
Inventor(s): KUBOTA YOJI; others: 01
Applicant(s): SANKYO SEIKI MFG CO LTD
Requested Patent: JP2109012
Application Number: JP19880261333 19881019
Priority Number(s):
IPC Classification: G02B26/10; G02B3/06
EC Classification:
Equivalents:

Abstract

PURPOSE:To reduce or prevent the ununiformity of the spot diameter on the scanning surface by providing a second lens group consisting of an image forming lens provided with an ftheta characteristic and an image bending correcting lens having a special toric surface on a deflecting device side between the deflecting device and the scanning surface. CONSTITUTION:A second lens group for bring a luminous flux deflected by a rotary polygon mirror 4 to image formation in a shape of a spot on the scanning surface 7 is provided with an image forming lens 52 provided with an ftheta characteristic, and an image bending correcting lens 51 placed between the lens 52 and a deflecting device 4. The image bending correcting lens 51 is a troidal lens whose incident surface has a special toric surface of a shape obtained by rotating a shape given by an edge line 51A around a rotary axis RX. This special toric surface has a negative radius of curvature in the main scanning direction and has a positive radius of curvature in the sub-scanning direction. Also, power in the sub-scanning direction decreases as it is separated from an optical axis in the main scanning direction, therefore, an image bending in the sub-scanning direction as the whole second lens group can be corrected.

(19) JAPANESE PATENT OFFICE (JP)

(12) LAID-OPEN PATENT APPLICATION (A)

(51) INT. CL.: G 02 B 26/10 3/06

ID MARK: E

JAPANESE PAT. OFFICE No. 7348-2H 7036-2H

(11) LAID-OPEN PATENT APPLICATION
No. HEI. 2-109012

(43) LAID-OPEN on: April 20, 1990

No. OF INVENTIONS: 2

REQ. FOR EXAM.: NO

(7 PAGES (Japanese))

---

(54) TITLE OF THE INVENTION: Light scanning apparatus

(21) APPLICATION No.: SHO. 63-261333

(22) FILING DATE: October 19, 1988

(72) INVENTOR: Youji KUBOTA
c/o KABUSHIKI KAISHA SANKYO SEIKI SEISAKUJYO
5329 Shimosuwamachi, Suwa-gun, Nagano-ken

(72) INVENTOR: Toshiyuki INOUE
c/o NISSHIN KOUKI KABUSHIKI KAISHA YAMANASHI KOJYO
200 Wakamiko, Sutamacho, Kitakoma-gun, Yamanashi-ken

(71) APPLICANT: KABUSHIKI KAISHA SANKYO SEIKI SEISAKUJYO
5329 Shimosuwamachi, Suwa-gun, Nagano-ken

(74)ATTORNEY: Patent Attorney Hideharu WATANABE

SPECIFICATION

TITLE OF THE INVENTION

Light scanning apparatus

CLAIMS:

1. A light scanning apparatus comprising a light source, a first lens group for imaging a beam from the light source as a line image extending in a direction corresponding to main-scanning, a deflecting device, having a plurality of deflecting surfaces, for deflecting the beam about a position adjacent the line image formed by said first lens group, and a second lens group, disposed between the deflecting device and a surface to be scanned, for imaging the deflected beam as a spot on the surface to be scanned,

wherein said second lens group includes an imaging lens having a fθ property, and a field curvature correcting lens disposed between said imaging lens and said deflecting device, and said second lens group is effective to focus the deflected beam on the surface to be scanned with respect to a main scan direction, and is effective to make the surface to be scanned and the imaging position of the line image by the first lens group substantially conjugate with each other, and at least one surface is

a field curvature correcting surface, and

wherein said field curvature correcting lens is a special toroidal lens having a special toric surface at a deflecting device side;

wherein said special toric surface has a geometrically negative radius of curvature with respect to the main scan direction, and has a surface configuration provided by rotating, about an axis parallel with the main scan direction adjacent a surface to be scanned beyond the special toric surface, a configuration defined by a general equation of aspherical surface.

2. A light scanning apparatus according to Claim 1, wherein a radius of curvature R, on the optical axis, of a configuration of the special toric surface as seen in the sub-scan direction and the focal length of said second lens group satisfy:

$$0.3 < |R/f| < 1.0.$$

DETAILD DESCRIPTION OF THE INVENTION

(APPLICABLE FIELD OF INDUSTRY)

The present invention relates to a light scanning apparatus.

(PRIOR ART)

A light scanning apparatus is well-known which comprises a light source, a first lens group for

imaging a beam from the light source as a line image extending in a direction corresponding to main-scanning, a deflecting device, having a plurality of deflecting surfaces, for deflecting the beam about a position adjacent the line image formed by said first lens group, and a second lens group, disposed between the deflecting device and a surface to be scanned, for imaging the deflected beam as a spot on the surface to be scanned.

In such an optical scanning apparatus, in order to prevent the variation, in the sub-scan direction, of the main-scanning position, attributable to the mechanical error in the deflecting device, that is, so-called surface tilting, the second lens group comprises an imaging lens having a $f\theta$ function and a cylindrical lens disposed between the imaging lens and the deflecting device, so that, in the main scan direction, the deflected beam is imaged on the surface to be scanned, and in the sub-scan direction, the imaging position of a line image formed by the first lens group and the surface to be scanned are made substantially conjugate with each other (Japanese Patent Application Publication Sho 52- 28666, for example).

(PROBLEM TO BE SOLVED)

Such a light scanning apparatus involves the following problems.

In Figure 6, designated by reference numeral 1 is a semiconductor laser, and reference numeral 2 is a collimator lens. These elements constitute a light source and provide a substantially parallel beam. The substantially parallel beam from the light source is imaged as a line image LI which is elongated in a direction corresponding to the main-scanning, by the cylindrical lens 3 constituting the first lens group.

A rotatable polygonal mirror depicted by a reference numeral 4 functions as a deflecting device and has a plurality of deflecting surfaces, and it deflects the beam with the center of deflection adjacent the line image LI.

In Figure 6, designated by reference numeral 5 is an is an imaging lens, and reference numeral 6 is a cylindrical lens. The imaging lens 5 and the cylindrical lens 6 constitute a second lens group. The deflected beam from the rotatable polygonal mirror 4 is imaged in the form of a spot on the surface to be scanned 7 by the second lens group and scans the surface to be scanned 7. The direction in which the spot moves is the main scan direction. The direction perpendicular to the main scan direction in the surface to be scanned 7 is the sub-scan direction.

The second lens group functions to provide a conjugate relation between the imaging position of the line image LI and the surface to be scanned in the

sub-scan direction. Therefore, in the sub-scan direction, an image of the line image is formed on the surface to be scanned 7 by the second lens group.

On the other hand, the deflected beam incident on the second lens group remains a parallel beam with respect to main scan direction, and the second lens group provides a conjugate relation between the infinity position in the object side and the position of the surface to be scanned 7 with respect to the main scan direction.

In order to acquire such an anamorphic property, the second lens group has to have a stronger power in the sub-scan direction as compared with that in the main scan direction. For this reason, the cylindrical lens 6 does not have power in the main scan direction but has a positive power in the sub-scan direction.

The imaging lens 5 is a so-called fθ lens having a fθ function.

Figure 7 is a view of a portion between the center of deflection of the rotatable polygonal mirror 4 and the surface to be scanned 7, as seen in the sub-scan direction.

When the above-described second lens group is used, the correction of the astigmatism in the sub-scan direction is difficult because the power in the sub-scan direction is stronger than that in the

main scan direction, with the result that as shown in Figure 7, a locus 8 of the beam imaging point P in the sub-scan direction is curved in the form of arcuation toward the second lens group. Then, the deflected beam is divergent in the sub-scan direction away from the point P toward the surface to be scanned 7, and therefore, the diameter of the spot SP on the surface to be scanned 7 becomes larger in the sub-scan direction away from the optical axis of the second lens group in the main scan direction, so that spot diameter is not uniform in the main scan direction. For this reason, optical scanning is not possible with a high resolution exceeding 400dpi.

Accordingly, the present invention is made in consideration of the circumstances, and it is an object of the present invention to provide a novel optical scanning apparatus wherein the non-uniformity of the spot diameter can be effectively reduced or prevented.

(MEANS FOR SOLVING THE PROBLEM)

The description will be made as to the present invention.

The optical scanning apparatus comprises a light source, the first and second lens groups and a deflecting device.

The first lens group functions to focus the beam emitted from the light source to form a line

image extending in a direction corresponding to the main-scanning.

The deflecting device has a plurality of deflecting surfaces, and functions to deflect the beam about a position adjacent the imaging position of the line image formed by the first lens group.

The second lens group is disposed between the deflecting device and the surface to be scanned, and functions to focus the deflected beam into a spot on the surface to be scanned.

The second lens group, as shown in Figure 1, comprises an imaging lens 52 having a fθ property and a field curvature correcting lens 51 disposed between the imaging lens 52 and the deflecting device 4 to function to image the deflected beam on the surface to be scanned in the main scan direction and to function to provide a substantially conjugate relation between the imaging position of the line image by the first lens group and the surface to be scanned.

The field curvature correcting lens is a special toroidal lens having a special toric surface at the deflecting device side.

The special toric surface has a configuration which has a geometrically negative radius of curvature with respect to the main scan direction, and a surface configuration provided by rotating, about an axis parallel with the main scan direction adjacent the

surface to be scanned beyond the special toric surface, a configuration defined by a general equation of aspherical surface.

The optical scanning apparatus as defined in Claim 2 includes the following further feature in addition to the features of Claim 1. Namely, the radius of curvature R on the optical axis in the configuration of said special toric surface as seen in the sub-scan direction, and the focal length f of said second lens group satisfy:

$$0.3 < |R/f| < 1.0.$$

The imaging lens having the fθ function may be a single lens or a compound lens comprising two or more lens elements, and any surface of the lens may be aspherical surface.

(FUNCTION)

The inventions as defined in Claims 1 and 2 commonly includes the following features:

First, the second lens group is constituted by an imaging lens and a field curvature correcting lens, and secondly, a special toric surface for field curvature correction in the field curvature correcting lens is disposed closest to the deflecting device in the second lens group.

The invention of Claim 2, includes, in addition to the above-described feature, the feature that special toric surface satisfies $0.3 < |R/f| <$

P10 1.0.

Referring to Figure 2, the configuration of the field curvature correcting lens 51 will be described.

In Figure 2, the lenses are shown in a perspective view with a part of the configuration omitted. The left side in the Figure is an incident side, that is, the deflecting device side.

The field curvature correcting lens 51 is a special toroidal lens which is concave at the incident side as seen in the sub-scan direction. And, the incident side surface thereof constitutes a special toric surface.

The special toric surface has the following features. As seen in the sub-scan directing direction, the configuration of the special toric surface is given by a ridge line 51A of the special toric surface, and the configuration of the ridge line is expressed by a general formula of an aspherical surface. Therefore, the configuration includes a circle shape as a special case.

The special toric surface has a configuration provided by rotating the line defined by the ridge line 51A about a rotational axis RX.

The rotational axis RX is perpendicular to the optical axis and is parallel with the main scan direction, and it is disposed adjacent the surface to

be scanned beyond the special toric surface, that is, the righthand side area in Figure 2. As a result, when the field curvature correcting lens 51 is cut along a plane parallel both to the optical axis and the sub-scan direction, the configuration of the cut end of the special toric surface is circular. The radii of the circles take a minimum value on the optical axis, and increases away from the optical axis in the main scan direction.

Thus, the special toric surface geometrically has a negative radius of curvature in the main scan direction and has a positive radius of curvature in the sub-scan direction. And, the power in the sub-scan direction decreases away from the optical axis in the main scan direction. Therefore, the field curvature of the entirety of the second lens group in the sub-scan direction can be corrected.

The field curvature correcting lens 51 has hardly any power in the main scan direction.

The description will be made as to the significance of disposing the special toric surface for the field curvature correction at a position closest to the deflecting device in the second lens group.

Figure 9 shows the optical system of the optical scanning apparatus shown in Figure 6, which is expanded along the optical system.

In order to effect a good optical scanning operation, it is necessary that spot configuration of the scanning light is stabilized in the main- and sub-scan directions as described hereinbefore. The spot configuration may desirably circular or close to a circular shape. In consideration of the fact that spot is formed by a beam waist, in order to realize the substantially circular spot configuration, it is necessary that converging tendencies of the beam condensing on the surface to be scanned 7, in the main-scanning and sub-scan directions, are substantially equal to each other, in other words, that exit pupils NA of the second lens group for the converging beam in the main- and sub-scan directions are substantially equal to each other.

In Figure 9, since the cylindrical lenses 3, 6 have no power in the main scan direction, the imaging relationship between the semiconductor laser 1 and the surface to be scanned 7 is as shown by the solid line. On the other hand, in the sub-scan direction, since the cylindrical lenses 3, 6 have powers, the imaging beam between the semiconductor laser 1 and the surface to be scanned 7 is as indicated by hatching when the NAs in the main- and sub-scan directions are equal as described above. It will be understood that in order to satisfy the condition that NAs in the main- and sub-scan direction

are equal, the beam has to be restricted in the sub-scan direction as indicated by the hatching in Figure 9. However, doing so will reduce the usage of light.

In order to increase the usage of light is increased by avoiding this problem, the focal length of the cylindrical lens 3 may be increased to an extent equivalent to the focal length of the second lens group. However, if this is done, the optical scanning apparatus is upsized.

Figure 5 shows the optical scanning apparatus expanded along the optical path. In this Figure, the second lens group is indicated as a single lens 50.

In the present invention, the anamorphic property of the second lens group is realized by the special toric lens, and the special toric lens is disposed at the incident side of the imaging lens closely to the imaging lens. In addition, the special toroidal surface is the closest to the deflecting device 4, and therefore, the object side focal length of the second lens group in the sub-scan direction can easily be made substantially the same as the focal length of the cylindrical lens 3. The exit pupil diameters NA of the second lens group in the main and sub-scan directions, can be made substantially equal to each other as shown in Figure, and the usages of the light in the main and sub-scan directions are made

substantially equal, and therefore, the usage of the light can be significantly improved without upsizing the optical scanning apparatus.

The description will be made as to the condition, in Claim 2, that is:

$$0.3 < |R/f| < 1.0.$$

Here, R is a radius of curvature, on the optical axis, of a configuration of the special toric surface as seen in the sub-scan direction, and f is a focal length of the second lens group.

The condition determines a practical range of the field curvature correction in the sub-scan direction. If the lower limit is exceeded, the correction of the field curvature is excessive with the result that field curvature increases in the positive direction. If the upper limit is exceeded, the correction of the field curvature is not sufficient. Accordingly, the range is practical.

The lens surface, at the surface adjacent the surface to be scanned, of the field curvature correcting lens 51, that is, the surface r2 is formed by a spherical surface or aspherical surface which is symmetric with respect to the optical axis. With such a formation, the machinability is improved, and the cost is reduced, and in addition, the optical characteristics are stabilized, as compared with the frequently used special configuration case wherein the

powers in the main scan direction and the sub-scan direction are different from each other.

On the contrary, when the imaging lens is constituted by a single lens, the radius of curvature r4 on the optical axis of the emergent side lens surface, and the focal length of the second lens group, desirably satisfy

$$0.4 < |r4/f| < 1.5.$$

This condition is concerned with the $f\theta$ property, and if the upper limit is exceeded, the negative distortion remarkably increases, with the result that $f\theta$ property is not sufficient, and the curvature of the image surface in the negative direction increases. If the lower limit is exceeded, the negative distortion decreases too much, and a sufficient $f\theta$ property is not provided. Therefore, it is desirable to satisfy the condition from the practical standpoint.

(EMBODIMENT)

Two detailed examples will be described.

In implementing the embodiments, the light source and the first lens group may be a combination of a known light source device emitting aforcal beam and a cylindrical lens having positive power, for example, a combination disclosed in Japanese Patent Application Publication Sho 52-2866.

In the following embodiments, only the data

of the second lens group which constitutes the characterizing portion.

In each of the embodiments, as shown in Figure 1, the second lens group is constituted by the field curvature correcting lens 51 and the imaging lens 52 which is a single lens.

As shown in Figure 1, the radii of curvatures of the respective surfaces are r0, r1x, r1y, r2x, r2y, r3, r4 from the deflecting device 4 side, and the spaces are d0, d1- d4. Suffix "X" in the radii of curvatures indicates those in the main scan direction, and "Y" indicates those in the sub-scan direction.

In each of the embodiments, j= 1 indicates field curvature correcting lens, j= 2 indicates imaging lens, and nj are refractive indices of the materials of the lenses.

Example 1

i	rx, y	d1	j	nj	material
0	∞	46.0			
1x	-92.500	6.0	1	1.486	acrylic resin
1y	29.480				
2x	-92.500	5.0			
2y	-92.500				
3*	399.434	25.0	2	1.486	acrylic resin
4	-111.618	175.122			

$R/f=r1x/f=-0.514$, $r4/f=-0.62114$, The focal length of the second lens group: $f=179.7$ In this embodiment, the configuration of the special toric surface in the main scan direction, that is, the configuration of the special toric surface as seen in the sub-scan direction, is arcuate with a radius of curvature $r1x=-92.500$, and the radius of curvature of the special toric surface on optical axis in the sub-scan direction is $r1y=29.480$.

The lens surface of the imaging lens at the incident side (with asterisk) is aspherical surface, and it is expressed by a known general formula of aspherical surface, as follows:

$$X = \{(1/r)^2Y^2\}/[1+\sqrt{1-(1+k)(1/r)^2}]$$
$$+AY4+BY^6+CY^8+DY^{10}$$

where the conical constant k, the high order non-spherical coefficients A, B, C, D are: $k=-3.26973\cdot10^{-1}$

$$A=-1.57\quad53\cdot10^{-7},\ B=5.90134\cdot10^{-11}$$
$$C=-1.97907\cdot10^{-14},\quad D=2.52778\cdot10^{-1}$$

Figure 3 shows aberration diagrams of Embodiment 1.

Example 2

i	rx, y	d1	j	nj	material
0	∞	46.0			
1x*	-92.500	6.0	1	1.486	acrylic resin
1y	29.480				
2x	-92.500	5.0			
2y	-92.500				
3*	399.434	25.0	2	1.486	acrylic resin
4	-111.618	175.122			

$R/f = r1x/f = -0.514$, $r4/f = -0.62114$,

The focal length of the second lens group: f= 179.7 In this embodiment, the configuration of the special toric surface in the main scan direction, that is, the configuration of the special toric surface as seen in the sub-scan direction, is expressed by the general formula of aspherical surface, and the radius of curvature of the special toric surface on optical axis in the sub-scan direction is r1y= 29.480.

The lens surface of the imaging lens at the incident side (with asterisk) is also an aspherical surface.

K, A, B, C, D defining the non-spherical configuration are as follows:

The configuration of the special toric surface in the main scan direction:

$k = -6.32029 \cdot 10^{-1}$

$A = 6.70608 \cdot 10^{-9}$, $B = 5.99831 \cdot 10^{-12}$

The lens surface of the imaging lens at the incident side

$k=-1.39881$

$A=-2.03709 \cdot 10^{-7}$, $B=5.14928 \cdot 10^{-11}$

$C=-1.26063 \cdot 10^{-14}$, $D=1.41459 \cdot 10^{-18}$

Figure 4 shows aberration diagrams of Embodiment 1.

(ADVANTAGEOUS EFFECT OF THE INVENTION)

As described in the foregoing, a novel optical scanning apparatus can be provided. In the optical scanning apparatus, the second lens group has a field curvature correcting surface, and the field curvature correcting surface corrects the field curvature in the sub-scan direction, and therefore, the variation of the spot configuration on the surface to be scanned can be effectively reduced or prevented. Accordingly, it is usable for optical scanning with high resolving power such as 400- 800dpi.

In addition, the field curvature correcting surface is disposed at a position closest to the deflecting device, the second lens group can be downsized, so that light usage can be remarkably improved without upsizing the apparatus.

These and other objects, features and advantages of the present invention will become more

apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

Figure 1 illustrates a structure of a lens which includes the feature of the present invention; Figure 2 illustrates the characterizing feature; Figures 3 and 4 are aberration diagrams of embodiments; Figure 5 illustrates advantageous effects of the present invention; Figure 6 through Figure 9 illustrate prior-art and problems involved therein.

LI =line image:

3= cylindrical lens:

52= imaging lens

51= field curvature correcting lens.

Applicant: (223) Kabushiki Kaisha Sankyoseiki Seisakusho

第 1 図

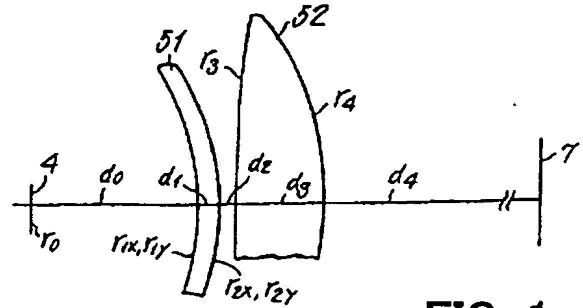


FIG. 1

第 2 図

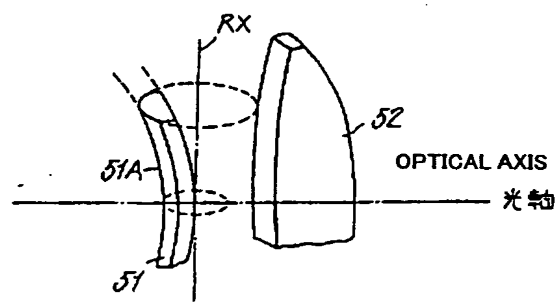


FIG. 2

第 3 図

SPHERICAL ABERRTION

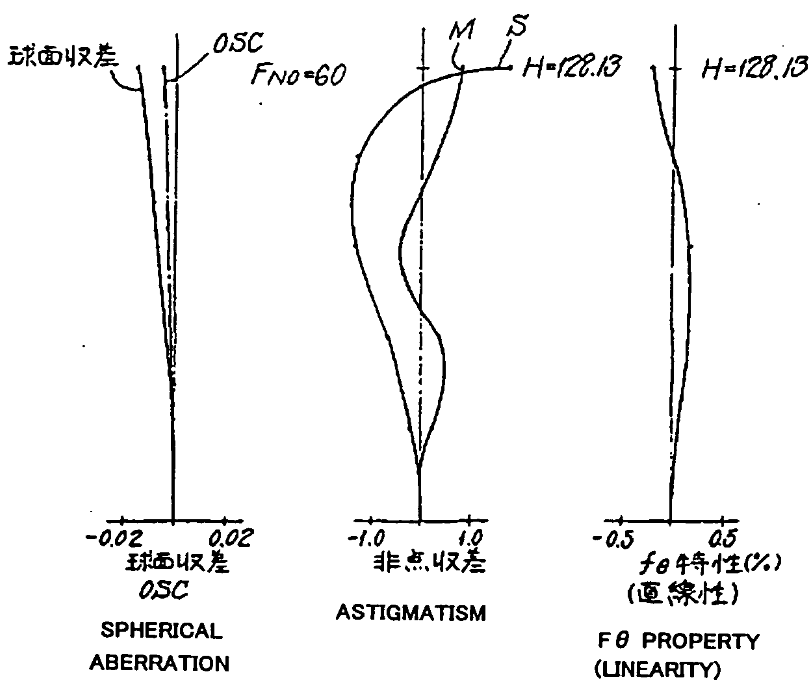


FIG. 3

第 4 図

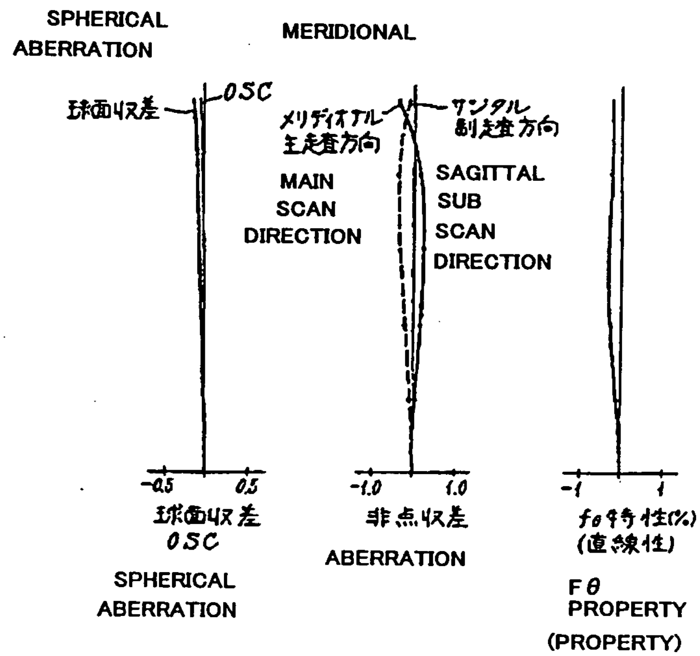


FIG. 4

第 5 図

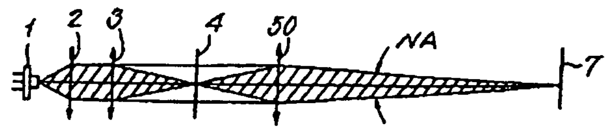


FIG. 5

第 6 図

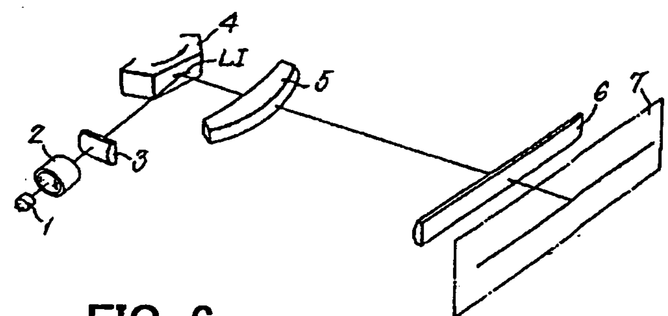


FIG. 6

第 7 図

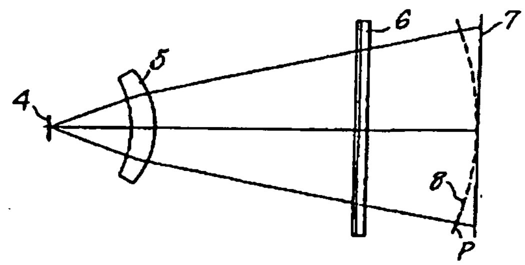


FIG. 7

第 8 図

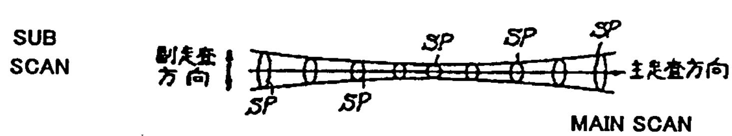


FIG. 8

第 9 図

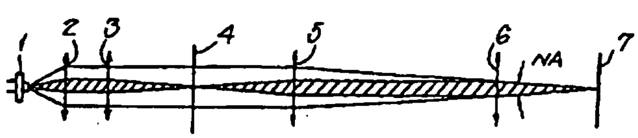


FIG. 9

⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　平2－109012

⑤Int. Cl.⁵　識別記号　庁内整理番号　㊸公開　平成2年(1990)4月20日

G 02 B 26/10　E　7348－2H
3/06　7036－2H

審査請求　未請求　請求項の数 2　(全7頁)

㊹発明の名称　光走査装置

㉑特　願　昭63－261333
㉒出　願　昭63(1988)10月19日

㉗発明者　久保田　洋治　長野県諏訪郡下諏訪町5329番地　株式会社三協精機製作所内

㉗発明者　井上　利幸　山梨県北巨摩郡須玉町若神子200番地　日新工機株式会社山梨工場内

㉗出願人　株式会社三協精機製作所　長野県諏訪郡下諏訪町5329番地

㉗代理人　弁理士　渡辺　秀治

明　細　書

発明の名称

光走査装置

特許請求の範囲

光源と、この光源からの光束を主走査対応方向に長い線像に結像させる第1レンズ群と、複数の偏向面を有し上記第1レンズ群による上記線像の近傍を偏向の起点として光束を偏向させる偏向装置と、この偏向装置と走査面との間に配備され偏向光束を走査面上にスポット状に結像させる第2レンズ群とを有し、

上記第2レンズ群は、fθ特性を備えた結像レンズと、この結像レンズと上記偏向装置との間に配備される像面湾曲補正レンズとを有し、主走査方向に関して、偏向光束を走査面上に結像させるとともに副走査方向に関しては上記第1レンズ群による線像の結像位置と走査面とを略共役な関係とする機能を有し、

上記像面湾曲補正レンズは、上記偏向装置側に特殊トーリック面を持つ特殊なトロイダルレンズであり、

上記特殊トーリック面は、幾何光学的には主走査方向に関しては負の曲率半径を持ち、副走査方向から見た形状が非球面の一般式に従う形状であり、この形状を特殊トーリック面より走査面側にあって主走査方向に平行な回転軸の回りに回転させて得られる形状であることを特徴とする光走査装置。

2．請求項1に於いて、

特殊トーリック面を副走査方向から見た形状に於ける光軸上の曲率半径をR、第2レンズ群の焦点距離をfとするとき、これらが

$$0.3 < |R/f| < 1.0$$

なる条件を満足することを特徴とする、光走査装置。

発明の詳細な説明

(産業上の利用分野)

本発明は、光走査装置に関する。

(従来の技術)

光源と、この光源からの光束を主走査対応方向

に長い線像に結像させる第1レンズ群と、複数の偏向面を有し第1レンズ群による上記線像の近傍を偏向の起点として光束を偏向させる偏向装置と、この偏向装置と走査面との間に配置され偏向光束を走査面上にスポット状に結像させる第2レンズ群とを有する光走査装置は良く知られている。

このような光走査装置では偏向装置の機械的な誤差に起因する、主走査位置の副走査方向への変動、即ち所謂面倒れを防止するために、第2レンズ群を、fθ機能を持つ結像レンズと、この結像レンズと偏向装置の間に配されるシリンドリカルレンズとにより構成し、主走査方向に関しては偏向光束を走査面上に結像させ、副走査方向に関しては第1レンズ群による線像の結像位置と走査面とを略共役の関係にすることが行われている(例えば、特公昭52-28666号公報)。

(発明が解決しようとする課題)

このような光走査装置には、以下の如き問題があった。

第6図で、符号1は半導体レーザー、符号2はコリメートレンズを示す。これらは光源を構成し略平行な光束を与える。光源からの略平行な光束は、次いで第1レンズ群をなすシリンドリカルレンズ3により主走査対応方向を長手方向とする線像LIに結像される。

符号4をもって示す偏向装置としての回転多面鏡は複数の偏向面を有し、線像LIの近傍を偏向の起点として光束を偏向させる。

第6図において、符号5は結像レンズ、符号6はシリンドリカルレンズを示す。これら結像レンズ5、シリンドリカルレンズ6は、第2レンズ群を構成する。回転多面鏡4により偏向される偏向光束は、上記第2レンズ群により走査面7上にスポット状に結像し、走査面7を走査する。このときスポットの移動する方向が主走査方向である。また、走査面7上に於いて主走査方向と直交する方向が副走査方向である。

第2レンズ群は、副走査方向に関しては上記線像LIの結像位置と走査面とを略共役の関係としている。従って副走査方向に関しては上記線像の像が、第2レンズ群により走査面7上に結像する。

一方、第2レンズ群に入射する偏向光束は主走査方向に関しては平行光束のままであり、第2レンズ群は主走査方向に関しては、物体側の無限遠と走査面7の位置とを共役関係とする。

このようなアナモフィックな性格を持つために第2レンズ群は、主走査方向に比して副走査方向のパワーが大きくなければならない。このためシリンドリカルレンズ6は主走査方向にパワーを持たず、副走査方向に正のパワーをもっている。

なお、結像レンズ5は所謂fθレンズであってfθ機能を有する。

第7図は、第6図に於ける回転多面鏡4による偏向の起点から走査面7までの間の部分を副走査方向から見た状態を示している。

上記の如き第2レンズ群を用いると、副走査方向のパワーが主走査方向のパワーより大きいため副走査方向での非点収差の補正が困難となり、第7図に示すように、副走査方向での光束結像点Pの軌跡8は円弧状に第2レンズ群側へ湾曲してしまう。すると、上記P点より走査面7側へ向かうにつれて偏向光束は副走査方向に於いて発散性となるから、第8図に多少誇張して示すように、走査面7上のスポットSPは、主走査方向へ第2レンズ群の光軸を離れるに従って副走査方向のスポット径が次第に大きくなってしまい、スポット径が主走査方向に於いて均一にならない。このため400dpi以上のような高分解能の光走査を行うことができない。

本発明は上述した事情に鑑みてなされたものであって、その目的とする所は、上記スポット径の不均一を有効に軽減ないし防止しうる新規な光走査装置の提供にある。

(課題を解決するための手段)

以下、本発明を説明する。

請求項1の光走査装置は、光源と、第1，第2レンズ群と、偏向装置とを有する。

第1レンズ群は、光源からの光束を主走査対応方向に長い線像に結像させるためのレンズ群である。

置は、複数の偏向面を有し第1レンズ群
像の結像位置の近傍を偏向の起点として
向させる装置である。
ンズ群は、この偏向装置と走査面との間
れ偏向光束を走査面上にスポット状に結
レンズ群である。
2レンズ群は第1図に示すように、fθ
えた結像レンズ52と、この結像レンズ52
置4との間に配備される像面湾曲補正レ
を有し、主走査方向に関して偏向光束を
に結像させるとともに副走査方向に関し
第1レンズ群による線像の結像位置と走
略共役な関係とする機能を有する。
面湾曲補正レンズは、上記偏向装置側に
リック面を持つ特殊なトロイダルレンズ

殊トーリック面は、幾何光学的には主走
関しては負の曲率半径を持ち、副走査方
た形状が非球面の一般式に従う形状であ
形状を特殊トーリック面より走査面側に

あって主走査方向に平行な回転軸の回りに回転させて得られる形状である。

請求項2の光走査装置は、上記請求項1の光走査装置の特徴に加えてさらに次の特徴を有する。即ち、特殊トーリック面を副走査方向から見た形状に於ける光軸上の曲率半径をR、第2レンズ群の焦点距離をfとするとき、これらが

$$0.3 < | R/f | < 1.0$$

なる条件を満たすことである。

fθ機能を持つ結像レンズは、単レンズであっても良く、あるいは2枚以上の複合レンズであっても良く、更にこれらのうちのいずれかの面を非球面で形成しても良い。

（作　　用）

本発明は，請求項1，2の発明を通じて以下の如き特徴を主として有する。

第1は、第2レンズ群が結像レンズと像面湾曲補正レンズにより構成されること、第2は、上記像面湾曲補正レンズに於いて実際に像面湾曲補正を行うための特殊トーリック面が第2レンズ群中

向装置よりに配されていることである。
請求項2の発明では上述の特徴に加えて
リック面が上述の条件0.3<| R/f |<1.0
る。
先ず上記像面湾曲補正レンズ51の形状
第2図を参照して説明する。
で各レンズはその形状の一部を切り欠か
で斜視図的に示されている。図の左側が
う偏向装置側である。
補正レンズ51は、副走査方向から見る
に凹形状をなす特殊なトロイダルレン
そしてその入射側の面が特殊なトーリ
成する。
なトーリック面は以下の如き特徴を持
即ち、この特殊トーリック面を副走査
ると、その形状は特殊トーリック面の
より与えられるが、この稜線の形状は
般式により表される。従って、この形
場合として円形状を含んでいる。
リック面は、上記稜線51Aで与えられ

る形状を回転軸RXの回りに回転して得られる形状を有する。

回転軸RXは光軸に直交し、主走査方向に平行であって、且つ特殊トーリック面よりも走査面側、即ち第2図で右側にある。この結果、像面湾曲補正レンズ51を光軸、副走査方向の双方に平行な平面で切断すると特殊トーリック面の切り口の形状は円形状となり、この円の半径は光軸上で最も小さく、光軸から主走査方向へ離れるに従って大きくなる。

かくして、特殊トーリック面は幾何光学的には、主走査方向には負の曲率半径を持ち、副走査方向には正の曲率半径を持つ。そして副走査方向のパワーは光軸を主走査方向に離れるに従い減少する。従って、第2レンズ群全体としての副走査方向の像面湾曲の補正が可能となる。

なお、像面湾曲補正レンズ51は主走査方向には殆どパワーを持たない。

次に、像面湾曲補正を行うためのかかる特殊トーリック面を、第2レンズ群中の最も偏向装置よ

ー1と走査面7と
の如く主・副走査
を施した光束部分
NAを等しくすると
副走査方向の光束
込む必要があり、
てしまう。
効率をあげるには
距離を第2レンズ
すれば良いが、こ
型化を招来してし

置を光路に沿って
符号50は第2レン
示している。
アナモフィックな
により実現され、
ンズが結像レンズ
て置かれ、さらに
に最も近接してい

の走査面側のレン
または非球面によ
成されることによ
主走査方向と副走
特殊形状のものに
になると同時に光
ることができる。
で構成する場合、
の曲率半径をr_4、
するとき、これら

い。
るものであって、
く増大しfθ特性
なり、また像面の
た、下限を越える
はり十分なfθ特
の条件の充足が実

用上からして望ましい。

［実施例］

以下、具体的な実施例を２例挙げる。

各実施例を実現する上で、光源及び第１レンズ群としては、平行光束を放射する公知の光源装置と正のパワーを持つシリンドリカルレンズとを組合せたもの、例えば前述の特公昭52-28666号公報記載のもの等を用いることができる。

以下に挙げる実施例では、特徴部分を構成する第２レンズ群のみのデータを挙げる。

各実施例とも、第１図に示すように像面湾曲補正レンズ51と単レンズの結像レンズ52とにより第２レンズ群が構成されている。

第１図に示すように、各面の曲率半径を偏向装置４の側から$r_0, r_{1x}, r_{1y}, r_{2x}, r_{2y}, r_3, r_4$、面間隔を$d_0, d_1$～$d_4$とする。曲率半径に於ける添字のＸは主走査方向に関するものであることを、Ｙは副走査方向に関するものであることを示す。

また各実施例に於いてj=1 は像面湾曲補正レンズ、j=2は結像レンズを表し、n_jはこれらレンズの材質の屈折率を示す。

実施例１

i	$r_{ix,y}$	d_i	j	n_j	材質
0	∞	46.0			
1_x	-92.500	6.0	1	1.486	アクリル
1_y	29.480				
2_x	-92.500	5.0			
2_y	-92.500				
3^*	399.434	25.0	2	1.486	アクリル
4	-111.618	175.122			

$R/f=r_{1x}/f=-0.514, r_4/f=-0.62114$, 第２レンズ群の焦点距離:f=179.7

この実施例に於いて、特殊トーリック面の主走査方向の形状即ち、特殊トーリック面を副走査方向から見た状態での形状は曲率半径$r_{1x}=-92.500$の円弧形状であり、この特殊トーリック面の光軸上に於ける副走査方向の曲率半径が上記$r_{1y}=29.480$である。

また結像レンズの入射側レンズ面（＊印を付けた面）は非球面であり、

公知の非球面の一般式を

$$X=\{(1/r)^2Y^2\}/[1+\sqrt{1-(1+k)(1/r)^2}]$$
$$+AY^4+BY^6+CY^8+DY^{10}$$

とするとき、円錐定数ｋ、高次の非球面係数 A,B,C,Dは以下の値を取る。

$k=-3.26973\cdot10^{-1}$

$A=-1.57653\cdot10^{-7}$,$B=5.90134\cdot10^{-11}$

$C=-1.97907\cdot10^{-14}$,$D=2.52778\cdot10^{-18}$

実施例１に関する収差図を第３図に示す。

実施例２

i	$r_{ix,y}$	d_i	j	n_j	材質
0	∞	46.0			
1_x	-92.500	6.0	1	1.486	アクリル
1_y	29.480				
2_x	-92.500	5.0			
2_y	-92.500				
3^*	399.434	25.0	2	1.486	アクリル
4	-111.618	175.122			

$R/f=r_{1x}/f=-0.514, r_4/f=-0.62114$, 第２レンズ群の焦点距離:f=179.7

この実施例に於いて、特殊トーリック面の主走査方向の形状即ち、特殊トーリック面を副走査方向から見た状態での形状は上記非球面の一般式で表される形状であり、この特殊トーリック面の光軸上に於ける副走査方向の曲率半径が上記$r_{1y}=29.480$である。

また結像レンズの入射側レンズ面（＊印を付けた面）も非球面である。

これらの非球面形状を規定する上記K,A,B,C,Dは以下の通りである。

特殊トーリック面の主走査方向の形状

$k=-6.32029\cdot10^{-1}$

$A=6.70608\cdot10^{-9}$,$B=5.99831\cdot10^{-12}$

結像レンズの入射側レンズ面

$k=-1.39881$

$A=-2.03709\cdot10^{-7}$,$B=5.14928\cdot10^{-11}$

$C=-1.26063\cdot10^{-14}$,$D=1.41459\cdot10^{-18}$

実施例２に関する収差図を第４図に示す。

（発明の効果）

以上、本発明によれば新規な光走査装置を提供

できる。この光走査装置では、第2レンズ群が像面湾曲補正面を有し、この像面湾曲補正面で副走査方向の像面湾曲を補正するので、走査面上のスポット形状の変動を有効に軽減ないし防止でき、従って400〜800dpiという高分解能の光走査にも対応することができる。

また、偏向装置に最近接させて像面湾曲補正レンズ面を配するので、第2レンズ群を小型化でき、また光走査装置の大型化を招来することなく、光利用効率を著しく向上させることができる。

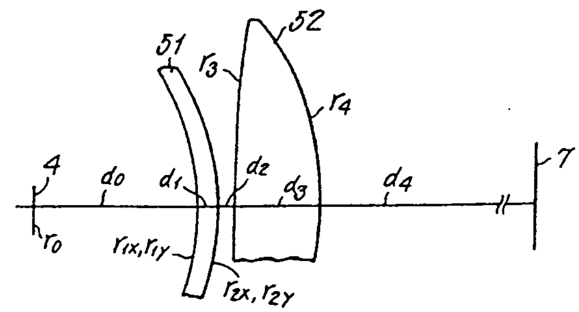
図面の簡単な説明

第1図は、本発明の特徴部分のレンズ構成を説明するための図、第2図は、上記特徴部分を説明するための図、第3図および第4図は、実施例に関連した収差図、第5図は、本発明の効果を説明するための図、第6図乃至第9図は、従来技術とその問題点を説明するための図である。

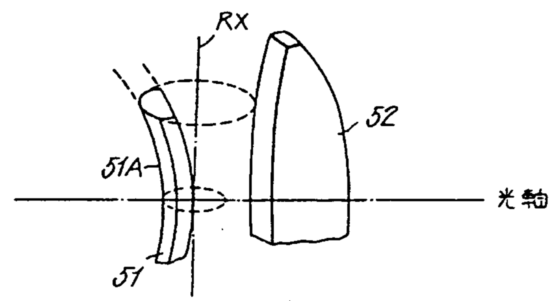
LI...線像、3...シリンドリカルレンズ、52...結像レンズ、51....像面湾曲補正レンズ

出願人 (223)株式会社三協精機製作所

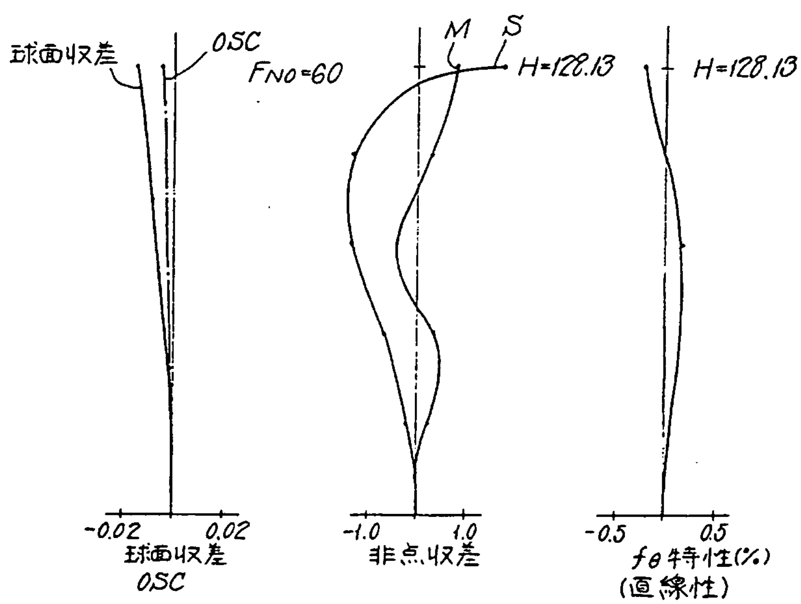
第1図



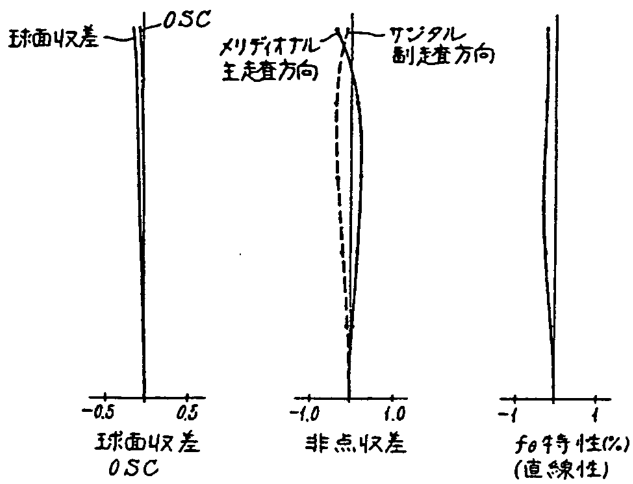
第2図



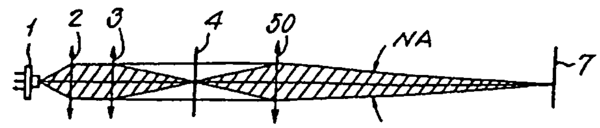
第3図



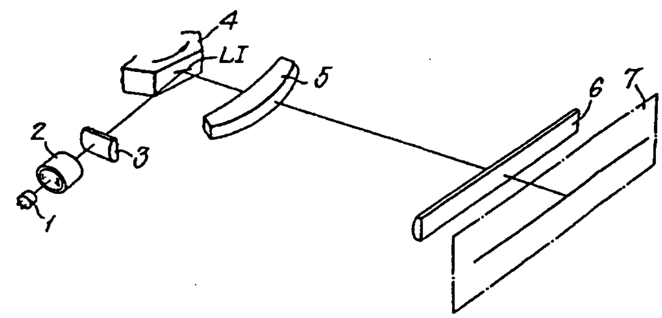
第4図



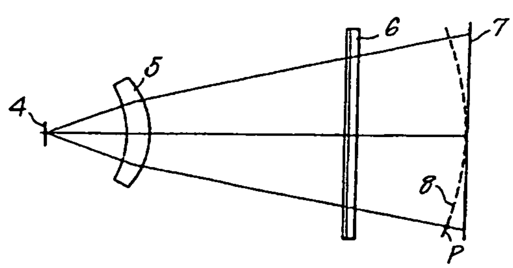
第5図



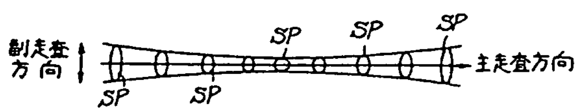
第6図



第7図



第8図



第9図